A-LEVEL
BIOLOGY

7402/2 Paper 2
Report on the Examination

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General Introduction to the Autumn Series

This has been another unusual exam series in many ways. Entry patterns have been very different from those normally seen in the summer, and students had a very different experience in preparation for these exams. It is therefore more difficult to make meaningful comparisons between the range of student responses seen in this series and those seen in a normal summer series. The smaller entry also means that there is less evidence available for examiners to comment on.

In this report, senior examiners will summarise the performance of students in this series in a way that is as helpful as possible to teachers preparing future cohorts while taking into account the unusual circumstances and limited evidence available.

Overview of Entry

As with last year, exceptional circumstances preceded this series of exam papers. Again, there were some very impressive responses. However, this year there was a higher proportion of scripts displaying little evidence of progression beyond GCSE. The percentage of questions students did not attempt was also certainly higher than in previous years. Some of these questions assessed topics that are usually taught towards the end of a Biology A-level course. Due to the pandemic, teaching of these topics would have been disrupted. There was no evidence to suggest that students did not have enough time to complete all the questions on the exam paper.

Many of the questions were effective discriminators enabling the best students to fully display their skills across the range of assessment objectives. However, this was not the case for questions assessing mathematical skills which did not discriminate effectively. This year, there were examples of students misinterpreting questions and not following the rubric. This was certainly the case in question 10 where students are directed to ‘Use information in the passage…’ Many students did not follow this advice for question 10.1 and, in particular, for question 10.3, where over 50% of students failed to obtain any of the marks available. Mirroring last year’s responses, most students displayed a complete lack of understanding of probability, as required in question 09.3. Very few students could use the probability values provided to evaluate the data.

Perhaps not surprising under the circumstances, the overall performance on some questions related to the assessment of practical skills was disappointing, e.g. questions 03.1, 03.3 and 09.1. As in previous years, the imprecise use of scientific terminology and limited powers of expression prevented some students from accessing specific marking points. This was particularly evident in questions 02.2, 02.3, 03.3, 05.3, 06.2, 10.1 and 10.3.

Comments on Individual Questions

Question 1

It was disappointing to find that a third of students did not obtain a mark for question 01.1. A number of these students attempted to describe glycogenesis, glycogenolysis or gluconeogenesis. Some responses included a mixture of reactions from respiration and photosynthesis and referred to reduced NADP, RuBP and GP. Nevertheless, almost 50% of students obtained at least two marks, often by referring to the phosphorylation of glucose using ATP and to the production of reduced NAD. Although ATP production was mentioned in many responses, the idea of a net gain of ATP was not always clear. The most inaccessible mark point was the oxidation of triose phosphate to pyruvate. Most students who included this reaction in their answer simply referred to 'conversion' or 'breakdown' of triose phosphate to pyruvate. Consequently, fewer than 10% of students gained full marks.

Question 01.2 proved to be a very good discriminator. Approximately 46% of students obtained at least one mark, usually for referring to oxygen as the final electron acceptor (in the electron transfer chain). 22% of students obtained a second mark by explaining that malonate would decrease the production of reduced coenzymes/NAD/FAD or that fewer hydrogens would be removed during the Krebs cycle. Some students suggested that oxidative phosphorylation would not occur but provided no further details, or that no NAD or FAD would be produced. Others suggested that a lack of ATP caused a reduction in oxygen uptake. A common uncredited response was that only anaerobic respiration would occur, so less oxygen would be required. A few answers referred to photosynthesis and included references to NADPH and RuBP.

Question 2

It was surprising that only 13% of students obtained all three marks on question 02.1. Nevertheless, it proved to be an excellent discriminator. Approximately 59% of students obtained at least one mark, usually mark point 3, by referring to the (active) transport of sodium ions out of and (active) transport of potassium ions into the axon. However, a significant number of students incorrectly described the direction of transport of these ions or suggested that 2 sodium ions are transported out for every 3 potassium ions transported in. Another frequent misconception was to suggest that the sodium/potassium pump involved diffusion rather than active transport. The mark scheme enabled students to obtain full marks whether they based their explanations on the axon membrane being 'impermeable' or 'less permeable' to sodium ions (compared with potassium ions) in terms of diffusion. However, only a third of students obtained at least two marks as there was considerable confusion concerning the diffusion of ions through the axon membrane. It was not uncommon to find responses with ions diffusing in the wrong direction or contradictory statements within the same answer. Some students suggested that the axon membrane was impermeable to sodium and potassium ions.

Question 02.2 also had a very high discrimination index despite only 8% of students obtaining maximum marks. Relatively few students mentioned mark point 1, i.e. myelination provides (electrical) insulation. Several students, who did refer to insulation, suggested that myelin provided thermal insulation. Some of these students then suggested that the resulting higher temperature caused faster transmission of impulses in myelinated neurones. The most frequently credited mark related to using the term saltatory (conduction) to explain faster transmission in myelinated neurones. Students who attempted to explain this process often referred to 'impulses jumping from node to node' which was not credited. Better responses used the term depolarisation. Similarly, students who did not refer to depolarisation or action potential could not access mark

point 3 when explaining slower transmission of impulses along a non-myelinated neurone. Nevertheless, the question was an excellent discriminator and 73% obtained at least one mark and 36% two or more marks.

Question 02.3 was also a very good discriminator but not as effective as questions 02.1 and 02.2 on the same topic. Only 47% of students obtained at least one mark on this question. There was considerable variation in the responses which were not awarded marks. Some students simply ignored the respiratory inhibitor and explained how depolarisation occurs or explained how an action potential is produced. A significant number of students suggested that the inhibitor would block or change the shape of channel/carrier proteins in the membrane. A few students explained how neurotransmitters could be inhibited in synapses. Students obtaining a single mark often did so by explaining that the inhibitor would reduce production of ATP. Unfortunately, weaker responses suggested that 'energy could not be produced'. Most students who mentioned the decrease in ATP gained another mark by explaining that this would affect the sodium/potassium pump. However, as with question 02.1, there was a significant number of students who incorrectly described the function of the pump. Only 8% of students obtained maximum marks by fully explaining how a resting potential of 0 mV is eventually produced. Very few students came close to accessing mark point 3. Students who did obtain this mark often referred to the same concentration of ions either side of the membrane or to no net movement of these ions.

Question 3

57% of students obtained at least one mark for 03.1. The most frequently awarded mark was for reference to the production of IAA in the shoot tip. A significant number of students simply stated that the tip contained IAA. Despite **Figure 1** indicating that there wasn't a directional light source, many students described phototropism or in some instances geotropism. This misinterpretation was further demonstrated by references to the 'shaded side' or 'the tip providing shade'. Mark point 2, relating to the diffusion of IAA, was rarely credited. Consequently, only 7% of students obtained maximum marks. Approximately 27% of students obtained at least two marks. These students explained that (more) cell elongation would occur on one side of the shoot. Responses such as 'more growth' or 'more elongation' were not credited.

Considering 03.2 was a five-mark question and assessed evaluation skills, it was not a very effective discriminator. Approximately 91% of students obtained at least one mark and 50% at least three marks. Most students were able to refer to variables which should be controlled to provide a valid conclusion. The mark scheme credited a maximum of three variables from a list of six. Apart from mark point 4, 'shoots at same stage of growth/development', all the listed variables were frequently credited. Almost 21% of students obtained at least one mark in addition to providing three correct variables. Usually, this was mark point 8, describing how the calibration curve could be used to compare IAA concentrations. Very few students suggested repeats and the calculation of a mean. Consequently, only 3% of students obtained maximum marks. Common errors in weaker responses included adding known IAA concentrations to the agar blocks, plotting calibration curves for the two plant species being investigated and not realising that the shoots were kept in the dark to determine the degree of curvature.

Question 03.3 was not well answered and proved to be a very poor discriminator. Only 1% of students obtained both marks and 23% obtained one mark. Most students did not provide conclusions but simply described the results shown in **Table 1**. Students who did obtain a mark usually concluded that IAA had moved to the shaded side or had moved away from light. Very few students concluded that IAA was not broken down by light or was still produced in the dark. Many

incorrect answers referred to the effects of IAA in terms of bending or phototropism rather than its movement or production.

Question 4

52% of students obtained both marks for 04.1, often providing very clear and concise explanations in terms of males requiring only one recessive allele whereas females needed two. Almost 23% of students obtained one mark. These students often explained why males were likely to have white eyes but did not provide enough detail concerning females. One mark was also awarded to students who used the term gene rather than allele but provided a full explanation for males and females. Students failing to gain credit often omitted any reference to allele or gene and limited their explanation to the sex chromosomes. A number of responses referred to an X allele rather than an X chromosome or suggested that the allele was on the Y chromosome.

Approximately 73% of students obtained the mark for 04.2 by correctly identifying the results of a sex-linked cross.

Despite only 26% of students obtaining at least one mark and only 1% all three marks, 04.3 proved to be an effective discriminator. As with previous questions involving linkage, most students had difficulty explaining the results in **Table 2**. Many students simply explained the results in terms of a dihybrid cross involving dominant and recessive alleles, omitting to explain why a 1:1 ratio rather than a 1:1:1:1 ratio was produced. Some students suggested epistasis was involved or provided a list of possible reasons including independent segregation, mutation and linkage. Some students, who did attempt to explain why particular phenotypes did not appear in the results, suggested lethal combinations, differential reproduction, adaptation to the environment and random fertilisation. Only 9% of the students who obtained a mark for referring to linkage then obtained a mark for suggesting that no crossing over had occurred. Students who could then outline which gametes/genotypes were or were not produced for a third marking point were a rarity.

46% of students provided a correct answer in 04.4 to obtain all three marks. Approximately one in four students obtained two marks and 80% of students obtained at least one mark. Common errors preventing students obtaining all three marks included using five generations or including males and females in the answer or the calculation. There was no evidence of students providing a correct answer which was not in standard form.

Question 5

Question 05.1 was generally well answered with almost 52% of students obtaining both marks and 37% obtaining one mark. The most common errors included references to ‘active site’, ‘enzyme’ or ‘substrate’ which disqualified mark point 2. Some students simply stated that ‘insulin did not fit’ rather than ‘insulin was not complementary’. Other incorrect responses referred to an ‘antigen-receptor complex’ or suggested that the change was in the tertiary structure of the receptor. Some students used unacceptable abbreviations for tertiary structure or referred to a 3D shape.

Despite only 8% of students obtaining all three marks on question 05.2, it proved to be a very good discriminator. 82% of students gained at least one mark, invariably by stating that less or no AKT would be activated. Many students realised that this would reduce the movement of the vesicles but did not mention the (cell-surface) membrane. Similarly, a significant number referred to glucose (channel) proteins, but once again did not mention the (cell-surface) membrane. Weaker responses suggested that the vesicles contained glucose. The direction of movement of glucose

into or out of the cell was not always clear, and occasionally incorrect. Only the best answers stated that less glucose would enter the cell by diffusion.

Fewer than 3% of students obtained all three marks for question 05.3 and only 44% gained at least one mark. Nevertheless, it proved to be an excellent discriminator. It was evident that many of the students who failed to gain a mark did so due to poor use of terminology. For mark point 1, students often referred to a 'high amount' or 'high level' of glucose in the blood/filtrate rather than a 'high concentration'. Similarly, for mark point 2, students referred to PCT rather than providing the full name, proximal convoluted tubule, as outlined in the specification. Students were not given credit for suggesting that 'no glucose' would be absorbed rather than 'less glucose'. Many students failed to mention the site of glucose reabsorption or provided an incorrect location, often the collecting duct or distal convoluted tubule. Only the very best answers explained why co-transport/carrier proteins are unable to reabsorb all the glucose when there is a high concentration of glucose in the blood/filtrate.

Question 6

Almost 84% of students gained at least one mark and 40% at least two marks for question 06.1. The most common response to gain credit was related to 'healthy' or 'normal' (blood) cells being produced. Students gaining two marks often referred to no MDS/faulty/cancerous (blood) cells being produced, or that only healthy cells were produced. Students often understood that stem cells were able to renew or regenerate themselves and differentiate into other cells, but did not explain that they replicated or divided. Consequently only 10% of students obtained maximum marks.

Question 06.2 proved to be an excellent discriminator. Approximately 73% of students gained at least one mark and 42% at least two marks. Most students obtained mark point 1 by stating that AZA would reduce methylation (of DNA/cytosine/gene). Fewer students obtained mark point 2 by referring to the transcription/expression of the tumour suppressor gene. Often this was due to poor terminology such as 'switched on', but also due to clear errors such as 'translated'. More students had success in explaining the role of the tumour suppressor gene in controlling cell division and obtained mark point 3. Approximately 23% of students obtained all three mark points.

29% of students obtained both marks and 55% one mark for 06.3. The most frequently credited mark was that using conventional drugs enabled the effect of AZA to be compared. Students who referred to AZT but did not gain the mark failed to include the idea of a comparison. Conversely some responses simply stated 'for comparison' without any reference to AZT. A significant number of students appreciated that it would be unethical not to supply conventional drug treatment to cancer patients. Incorrect responses included reference to 'placebos', 'double-blind experiments' and 'side effects'.

Question 06.4, assessing mathematical skills, was a poor discriminator. Approximately 34% obtained two marks and 52% one mark. Students obtaining a single mark often did so for correct readings from the graph or for a final answer of 28 due to incorrect rounding of 28.8.

Question 7

Approximately 40% correctly performed the calculation in 07.1 for two marks. Approximately 24% of students obtained one mark, usually for showing '40' in the working. However, a significant number of students gained a mark for a final answer showing 625 but with the decimal point in the incorrect place, e.g. 6.25, 62.5, 6250. These students had often made an error when converting

units of measurement. Common incorrect answers were 2400 (60 000 divided by 25), 240 and 2.4.

Approximately 39% of students obtained the mark for 07.2, almost invariably by referring to the phospholipid bilayer. Only a handful of students gained the mark for suggesting that no carrier/channel proteins would be available for uptake of the RNAi molecules. Many of the responses which were not credited lacked sufficient detail, for example by stating that the cell-surface membrane has 'phospholipids', 'a lipid bilayer' or 'a lipid layer', or that the molecule was now 'lipid soluble'. More fanciful explanations involved the lipids acting as receptors and carrying the RNAi across the membrane. Others suggested that the RNAi had lipid receptors to which the lipid could bind.

07.3 was an excellent discriminator, the most effective on the paper. Approximately 80% of students gained at least one mark, and almost 14% obtained the maximum five marks. Although mark points 1, 4 and 10 were rarely awarded, all the points on the mark scheme were credited at some stage of marking. The most frequent mark awarded related to the investigation being on mice rather than on humans. Students who gained a mark by referring to the overlap in standard deviations often obtained another mark by stating that there was a significant difference in the effectiveness of the two types of RNAi. It was pleasing to note that few students referred to the 'results being significant'. However, a substantial number of students omitted any reference to the overlap in standard deviations but instead compared the spread of this data around the mean in terms of reliability of the results. Almost 47% of students gained at least three marks. There was some variation in how higher marks were achieved. The most frequent additional points related to long-term or side-effects not being known and the fact that sample size was unknown. However, a significant number of students did use the data in **Figure 8** to compare the effectiveness of the types of RNA. Less frequent were responses which referred to the lack of a statistical test to determine significance or references to the investigation being *in vitro* rather than *in vivo*.

Question 8

Considering that question 08.1 assessed knowledge and understanding, it was surprising and very disappointing that almost 20% of students did not attempt it. However, despite this and the fact that only 41% of students gained at least one mark, it proved to be an excellent discriminator. The most frequently credited response was reference to the breaking of hydrogen bonds by heating DNA at a high temperature (90° to 95°C). Students obtaining two or more marks often mentioned reducing the temperature enabling the binding of primers to the DNA. A common error among students who gained a maximum of two marks was to omit any reference to nucleotides, making marking points 1 and 4 inaccessible, or to omit one of the temperature changes required. Weaker responses included a variety of incorrect enzymes, most frequently RNA polymerase, but also reverse transcriptase, restriction endonuclease and ligase. References to just 'polymerase' were also common. Approximately 22% of students obtained at least three marks. One reason for students not gaining maximum marks was to incorrectly outline the role of DNA polymerase. Consequently, only 10% of students obtained all 4 marks.

Only 5% of students obtained both marks for question 08.2. Considering the difficulties most students had in describing and explaining the polymerase chain reaction in 08.1, this was not surprising. Most students simply described the shape of the curve in **Figure 9** rather than explaining it. The 22% of students who gained one mark for this question invariably obtained mark point 2. Most of these students explained the plateau in terms of lack of nucleotides or primers. Few responses referred to the eventual denaturation of DNA polymerase. Weaker responses frequently suggested that the number of DNA fragments was the limiting factor or that DNA

polymerase had been 'used up'. Students gaining both marks often included an explanation of the exponential increase due to doubling of the number of DNA molecules.

Question 9

Question 09.1 proved to be an excellent discriminator. Approximately 63% of students obtained at least one mark. Mark point 1, relating to a method of determining random numbers and mark point 2, referring to a large number of quadrats, appeared fairly frequently. Students who failed to obtain mark point 1 often referred to random numbers without providing a method or provided incomplete descriptions such as 'use a generator'. Similarly, for mark point 2, some students suggested too few samples, e.g. 1, 3 and 5 (common incorrect responses), rather than 'many' or 10 (or more) if a number was given. There were a few responses that suggested randomly throwing quadrats. The mark scheme accepted frames/squares for quadrats, which enabled more students to access this mark point. Punnett squares were not credited! Only 6% of students obtained all three marks. Most students failed to describe how the mean percentage cover could be determined. Many students suggested counting the number of algae in quadrats rather than the percentage cover or in some instances counting the number of species. Some students determined the percentage cover for one quadrat and stated that this should be used for the whole coral reef.

09.2 was also an excellent discriminator, especially for a two-mark question. Almost 21% of students obtained both marks and 32% obtained a single mark. A significant number of students who failed to gain a mark interpreted this question as being about speciation rather than succession. This resulted in explanations involving advantageous alleles and competition. Students who did gain credit found mark point 2 far more accessible than mark point 1. These students often referred to one or more of the following: 'more habitats', 'more food sources' or the development of a 'less hostile' environment. Responses which were not credited often stated that there would be 'more food' or that the area 'becomes hospitable'. Students who appreciated that this question concerned succession often failed to provide precise details for mark point 1. It was common to read responses that mentioned 'more plants', 'more algae' or less frequently 'more animals' rather than referring to an increase in species or biodiversity.

Despite only 1% of students obtaining the maximum five marks and 2% obtaining four marks, question 09.3 was an excellent discriminator. One contributory factor to few high marks was students only evaluating the data in **Table 3**, despite the question stating, 'Using all the information, evaluate…' Nevertheless, all the mark points did appear at some stage of marking, indicating that some students did follow the rubric. Another contributory factor to the low mean mark in this question was that an understanding of probabilities was required. More than 50% of the students incorrectly interpreted the probability values and suggested that the results from cages B and D were significantly different (from cage A) and that there was no significant difference between the results in cages C and A. Correctly interpreting the results often provided the only marks (mark points 1 and 2) for a significant minority of students. Few students attempted to explain the probability values in terms of $P \geq 0.05$ but these explanations often lacked clarity and usually confused the terms probability and chance. Most students did not consider the limitations of the investigation in terms of using an artificial reef, the time period of 34 weeks, the depth of 16-18 metres and the location, off the coast of Florida. Students who did often only mentioned one limitation. Most students who referred to the duration of the investigated thought that 34 weeks was more than sufficient time for the investigation.

Question 10

Question 10.1 was also an excellent discriminator even though almost a third of students failed to obtain a mark. Despite the question asking about speciation, a significant number of these students attempted to answer in terms of succession. Students who used the information in the passage often stated that populations of fish would become geographically isolated but did not necessarily mention allopatric speciation, mark point 2. However, most of these students obtained mark point 4, stating that reproductive isolation would occur. Many of these students also obtained mark point 6, i.e. different species cannot breed to produce fertile offspring. Weaker responses often omitted 'fertile offspring'. The 31% of students who obtained three or four marks did so in a variety of ways. Many did refer to a change in the frequency of alleles and to variation caused by mutations. However, it was not uncommon for students to refer to mutation without mentioning variation or to refer to genes rather than alleles. Similarly, a significant number of students mentioned different selection pressures or environmental conditions but not in the context of smaller/different lakes. It was evident that these students had not used the information in the passage and simply provided an explanation of speciation. This also led to several accounts of sympatric speciation. These students limited their explanations to speciation in a large lake. Although reference to the term 'sympatric' was not credited, these explanations could access most of the marking points and obtain maximum marks. Almost 12% of students obtained maximum marks on this question.

45% of students obtained both marks and 22% one mark for 10.2. A variety of successful methods were used to obtain two marks. Some immediately determined 15% of land area, while others approached it by determining 41.4% and 26.4% of land area and then obtaining the difference. Most students obtaining a single mark did so by showing 11 412 in their working. However, some students gained a single mark for performing a correct calculation using the total area of the country of Malawi (118 000 km^2) rather than the actual land area (94 080 km^2). Examiners were surprised to find responses in which the number of weeks in a year was shown as 48, 54 and even 60!

The main reasons for a low mean mark on question 10.3 were due to misinterpretation of the wording and failure to follow the rubric. Examiners commented that 50% of students explained how a loss of nutrients in Lake Malawi resulted in a decrease in some fish populations and consequently did not obtain any marks. The question asked students about the loss of nutrients **into** Lake Malawi. The word into was emboldened in the question to emphasise what was required. If these students had followed the rubric, i.e. 'Use information in the passage….' they would have understood that soil erosion had caused an increase in nutrients in Lake Malawi. Consequently, this question did not discriminate very effectively, and many students failed to gain credit. Students who misinterpreted this question often described competition between fish populations for the limited food available due to loss of nutrients. Students who did interpret the question correctly often gained mark point 1, i.e. increase in algae causing less light to enter the lake. Many of these students went on to obtain a second mark by explaining that submerged plants would die due to the inability to photosynthesise. Weaker responses often omitted any reference to photosynthesis. Only 17% of students obtained three or more marks. Students gaining three marks often did so by linking the death of fish to the inability to respire due to lack of oxygen. Students who did not obtain this mark point frequently failed to mention respiration. 6% of students gained maximum marks by including the role of saprobionts in using oxygen in respiration during decomposition. Unfortunately, some students only referred to bacteria or decomposers. Some students believed that decomposition released toxic products which resulted in the death of fish or that the nutrients were toxic. Other students considered the nutrients to be pesticides, both

insecticides and herbicides, and developed arguments to suit. These invariably related to food chains and reduced availability of food for fish.

Question 10.4 proved to be an excellent discriminator, with the second highest discrimination index on the paper. Four out of five students obtained at least one of the four marks available and 15% obtained maximum marks. Most students obtained mark point 1, the capture, marking and release of fish. Students who didn't often failed to mention the release of fish, presumably in their haste to answer the question. Ensuring that the marking of fish did not affect their survival was also frequently credited, enabling almost 60% of students to obtain at least two marks. Almost 40% of students obtained at least three marks, most of these students mentioning that sufficient time should be provided to allow fish to distribute before collecting a second sample. The failure of better responses to obtain maximum marks mainly involved errors in providing the equation used to estimate the fish population. There was a range of errors. Some students provided the correct equation but then multiplied by 100. More frequently, students added or subtracted, rather than multiplied the two sample numbers and/or divided by the total number of fish in the second sample.

Question 10.5 was not well answered and was a very poor discriminator. Approximately one in four students obtained the mark, usually for stating that it would be difficult to recapture fish in large lakes. Relatively few students gained credit for the alternative response that it is unlikely that fish would distribute randomly in large lakes. A significant number of students ignored the context of 'large lakes' and commented on possible errors in the procedure, such as 'the marking washing off' or fish 'not surviving'. Other common incorrect responses referred to births, deaths, immigration, emigration and migration.

Mark Ranges and Award of Grades

Grade boundaries and cumulative percentage grades are available on the Results Statistics page of the AQA Website.